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Treatment of Venous Malformations With an Intense Pulsed Light Source (IPLS) Technology: A Retrospective Study

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Background and Objective: **The intense pulsed light source (IPLS) technology provides an innovative concept in the treatment of vascular lesions. We investigated the effectiveness of IPLS in the treatment of venous malformations.**
Study Design/Materials and Methods: **A retrospective study of 11 patients with venous malformations (VMA) treated with IPLS was initiated. Clinical VMA characteristics recorded were size and location. Data collected included treatment parameters (filters, pulse duration, fluence, and pulse sequencing), % clearance, and side effects (e.g., swelling, blisters, crusting, pain, altered pigmentation, and scarring).**
Results: **Good and very good (70–100%) clearance was achieved in 8 malformations smaller than 100 cm². Especially small lesions needed only 2–3 treatments. Three VMA larger than 100 cm² could be cleared well in an average of 18 sessions. The most frequently used parameters were the 590 nm filter in long pulse mode, triple pulses, and fluences at an average of 80.4 J/cm². Side effects included prolonged erythema in 23.6, swelling in 17.9%, crusting in 4.7%. Bleeding, hypo-, hyperpigmentation, and scarring were rare (0.9% respectively).**
Conclusion: **IPLS presents an effective method for treating VMA, especially small malformations, with a justifiable rate of side effects when optimal parameters are chosen. Lasers Surg. Med. 25:170–177, 1999.** **© 1999 Wiley-Liss, Inc.**

Key words: PhotoDerm VL®; pulsed laser and light systems; venous malformations

Venous malformations manifest in a wide spectrum, from isolated cutaneous ectasias or a localized spongy mass, to a complex lesion involving multiple tissues and organs [1,2]. Possible complications of venous malformations are phlebothrombosis within a malformation, palpable, small thrombi with localized pain, or consumptive coagulopathy secondary to stasis, within the ectatic vascular channels. In the past, venous malformations could not usually be completely eradicated. Previous therapeutic modalities like excision, electrocoagulation, or sclerotherapy were accompanied by complications such as bleeding, pain, and scarring, or were limited by size and extension of vascular lesions [2,3]. In the last 15 years, several lasers such as the argon laser, the Nd:YAG (1,064 nm) laser, the KTP-frequency doubled Nd:YAG (532 nm) laser, the copper vapour laser, or flashlamp pumped pulsed dye lasers were used. However, in the treatment of large venous malformations, these lasers were limited either by a lack of response or a high rate of side effects [4–15].

Alternatively to laser systems, PhotoDerm VL® is an innovative, intense pulsed light source (IPLS) that emits polychromatic, noncoherent light. This new device utilizes light beams that may be varied in terms of wavelength, pulse duration, and fluence. Thus vascular lesions of vari-

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ous depth and size (e.g., Spider nevi, telangiectasia, port wine stains, poikiloderma of Civatte) and hypertrichosis can be treated effectively [16–24]. Benign venous malformations seem to be a further interesting indication for the IPLS because of their deep seated, large vessels and cavernous structures.

Treatment of venous malformations in 11 patients was performed by using these principles during the current clinical study of IPLS.

MATERIALS AND METHODS

From December 1994 to August 1998, 11 patients (seven female, four male) with 11 venous malformations were treated using an intense pulsed light source (IPLS) (Photoderm VL®, ESC-Sharplan Medical System Ltd., Haifa, Israel), emitting incoherent light with a wavelength continuum ranging from 515 to 1,000 nm. Depending on the characteristics of the lesion and the skin type, different filters (515, 550, 570, 590 nm) can be used which filter out shorter wavelengths. A single, double, or triple pulse can be administered. Pulse duration ranges between 0.5 and 25 ms in the short pulse mode and up to 30 ms in the long pulse mode. Fluence lies between 3 and 90 J/cm^2. Delay time between pulses is adjustable from 10 to 500 ms. The rectangular spot exposes an area of 2.8 cm^2 (8 × 35 mm).

All patients with venous malformations (VMA) undergoing an IPLS therapy were included in this retrospective study (Table 1). The ages of the patients ranged from three to 61 years. Two patients were under the age of 12 (three and 10 years). Three of the treated VMA were localized on the face and neck, four on the trunk, two on the legs, and two on the penis. Eight lesions were smaller than 100 cm^2; three VMA were larger than 100 cm^2. In five patients, color-flow Doppler sonography of the vascular malformation was carried out before treatment to define depth and thickness of the vessel malformations (HDI 3000; ATL USA, Inc.; transducer CL 10-5 compact linear array Entos™, ATL USA, Inc.). The depth ranged between 0.5 and 2 cm; the thickness between 0.4 and 2 cm. Six (54.5%) of the 11 VMA had previously been treated without success by surgical excision, sclerosing, laser, cryotherapy or x-ray therapy. In five patients, among them two children, local anaesthetics (2.5% Lidocain–2.5% Prilocain-cream; 10% Lidocain-spray) were applied before each IPLS therapy. Immediately before the treatment, an approximately 1 mm layer of a clear, cooled waterbased gel (Coupling Gel; ESC) was placed between the emitting crystal and the skin to decrease epidermal heating. Following treatment, ice-cold refrigerant packs were applied to the area for 20–30 minutes to treat the sunburn-like discomfort and to prevent inflammatory swelling. When crusting occurred, an antibiotic ointment (3% Chlortetracyclin) was required. Patients were advised to avoid sun exposure during the whole treatment period. Patients were treated with IPLS in intervals of 1–8 weeks.

TABLE 1. Patient Demographics

Number of patients		11
Male		4
Female		7
Age		3–61 years
< 12 years		2 (3 and 10 years)
Fitzpatrick skin type	I	4
	II	7
	III	—
	IV	—
Size of VMA		
< 100 cm^2		8
> 100 cm^2		3
Localization		
Face		2
Neck		1
Trunk		4
Legs		2
Penis		2
Previously treated VMA		6
Local anaesthesia (10% lidocain spray, 2.5% lidocain–2.5% prilocain cream)		5 patients (among 2 children)

Due to the retrospective character of our study, no uniform parameters were employed. The filters used were 550, 570, and 590 nm, total fluence ranged from 32 to 90 J/cm^2, and energy was applied in single, double, and triple sequential pulses.

Test patches were done. The fluences were raised corresponding to the appearance of adverse reactions and to lightening effect. Most of the lesions were treated twice over the same area (two passes per session), with the exception of the legs because of higher sensibility of the skin and poor lymphatic drainage there in comparison to other regions.

Photographs were taken under identical conditions. A Cannon EOS 100-camera with Agfa CTX 100 (Leverkusen, Germany) film was consistently used. Pre- and post-treatment photographs were evaluated by three physicians independently. The degree of clearance was determined.

Results were ranked into one of four categories: 85–100% clearance (very good), 70–84% clearance (good), and 50–69% clearance (fair), and less than 50% clearance (poor). The post-treatment presence or absence of prolonged erythema, swelling, blisters, bleeding, crusting, hypo- or hyperpigmentation, or scarring was recorded according to statements from the patients.

RESULTS

Venous Malformations < 100 cm^2

A very good clearance could be observed in seven cases after two to nine treatments. Good clearance was shown in one malformation. It is noteworthy that two small lesions (1.5 and 4 cm^2) only needed two and three treatments respectively, for 95% clearance (Fig. 1A,B). One VMA (with a thick nodular part) showed only 70% clearance after seven sessions (Table 2).

Venous Malformations > 100 cm^2

Treatment results for malformations larger than 100 cm^2 (n = 3) included three with good clearance. The average number of sessions in this group was 18 (Table 2; Fig. 2A,B).

Treatment Parameter

The total number of sessions in 11 patients was 106. Initially, the 590 nm filter was used for deep vessels (n = 95; 89.6%); here most treatments were applied in the long pulse mode (n = 73; 76.8%). For superficial parts of the lesions, the 570 nm filter (n = 9; 8.5%) and the 550 nm filter (n = 2; 1.9%) were required. Most treatments were carried out in sequences of triple pulses (n = 75; 70.7%; especially for deep vessels). The pulse duration sequence 5.0–6.6–8.7 ms was most frequent for the long pulse mode; 3.8–3.1–2.5 ms for the short pulse mode. Double pulses (n = 29; 27.4%) and single pulses (n = 2; 1.9%) were also employed but less frequently (especially for superficial vessels). Fluences ranged from 32 to 90 J/cm^2. The average fluency used in the short pulse mode was 50 J/cm^2; in the long pulse mode 80.4 J/cm^2.

Side Effects

Side effects included prolonged erythema in 23.6% of treatment sessions (n = 25), persisting for a maximum of five days, typically 24–72 hours. Immediate post-treatment swelling lasting only some hours was common. Swelling persisting longer than 24 hours was observed in 17.9% (n = 19), blisters in 2.8% of sessions (n = 3). In 4.7% (n = 5), crusting was noted that resolved within 1–2 weeks. Prolonged post-treatment pain (longer than 12 hours) occurred six times (5.7%). Bleeding, hypo-, hyperpigmentation, and scarring were rare (n = 1; 0.9% respectively) (Table 3).

DISCUSSION

Due to its specific way it works based on the principle of selective photothermolysis [25], the flashlamp-pumped pulsed dye laser (FLPDL; 577 or 585 nm) has proven itself an effective and safe method for treatment of various vascular lesions, e.g., port wine stains and initial hemangioma, over the past decade [26,27]. However, deep-seated vessels and cavernous malformations cannot be targeted successfully by the FLPDL beam because of its shallow penetration depth. Histologic studies demonstrated insufficient coagulation of dermal vessels below 1.16 mm in human skin [8,9,28]. With larger and deeper vessels, it is important to use longer wavelengths, longer pulses, and higher fluences. The IPLS utilizes a high energy flashlamp with variable wavelength spectrum, allowing the simultaneous application of longer wavelengths (515–1,000 nm). The concept of the IPLS is selective photothermolysis [29], as used in the dye laser. The target chromophore is oxyhemoglobin. Effective heating of the upper as well as deeper vessels could be obtained with the IPLS because of its wavelength spectrum [16]. Whereas the penetration depth increases at longer wavelengths, the absorption of laser energy in blood vessels decreases dramatically [30]. Concomitant increases in fluence are required to compensate for the decreased absorption and increased volume of blood being heated [11]. The IPLS allows for the application of high fluences in the so-called long pulse mode. With fluences of up to 90 J/cm^2, larger volumes of blood, e.g., in VMA, are sufficiently heated. Consequently, the blood in the vessels and caverns coagulates, partly felt as fixed thrombosis and detectable by ultrasound sonography. The vessels are injured by selective photothermolysis which leads to their destruction, removal, and replacement by granulation tissue [31].

The FLPDL is less effective for large vessels or multi-layer vessels also because of its short pulse duration (450 μs). Ideally, the pulse duration should be compatible with the diameter of the vessel and be about equal to the thermal relaxation time for that dimension [32–34]. If the laser

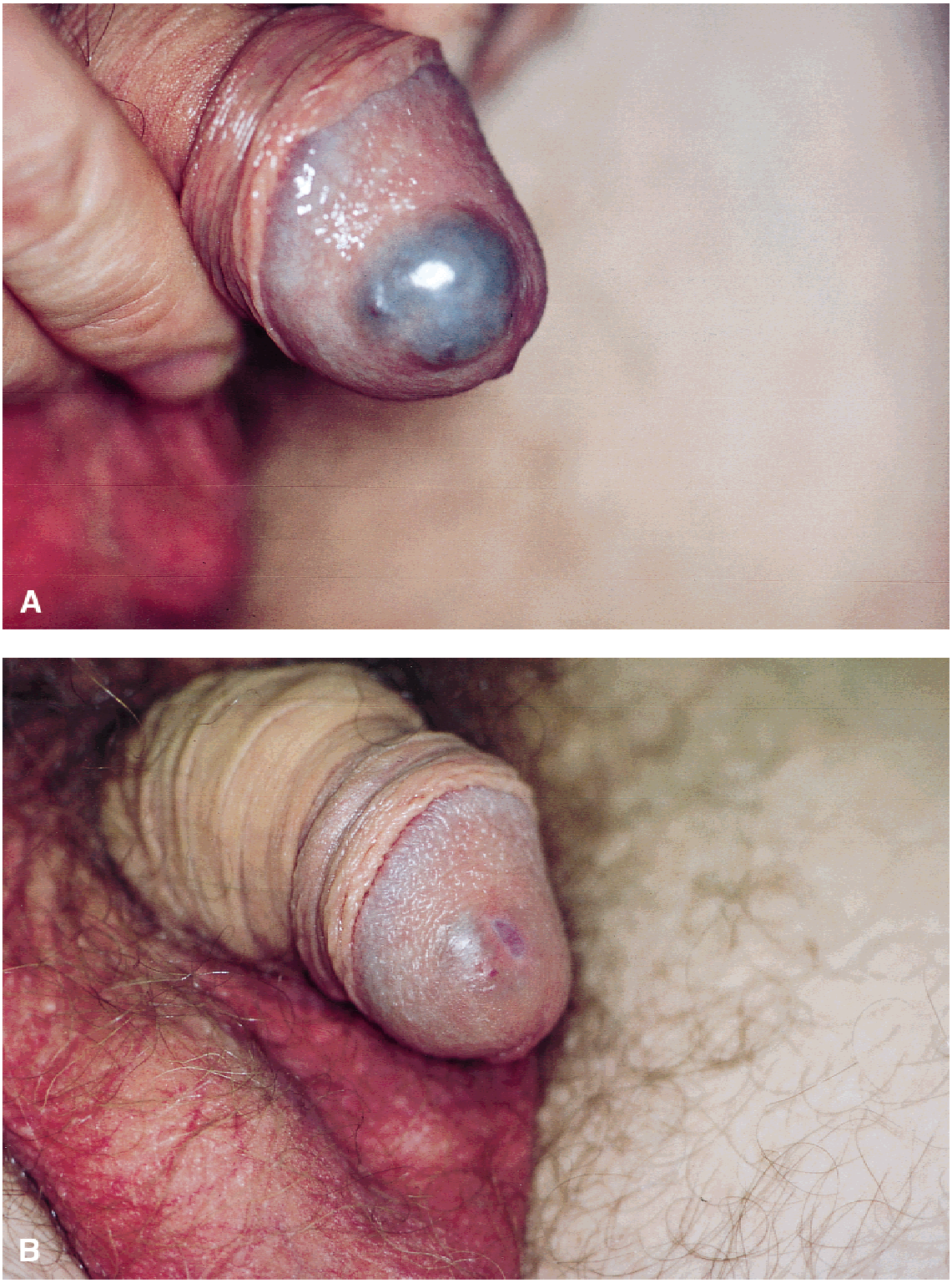

Fig. 1. **A:** A 35-year-old man with a small superficial venous malformation on the penis. **B:** A 95% clearance after two treatments with the PhotoDerm VL® with minimal textural change.

TABLE 2. Clearance (%) of Venous Malformations After IPLS Therapy in Relation to the Lesion Size

Sessions Size (cm^2)	1	2	3	4	5	6	7	8	9	10	11	12	> 12
1.5			95										
4		95											
8								100					
12								100					
15							95						
15							70						
40							95						
60									90				
140													80
190													70
260												80	

pulse duration is too short, heating will be confined to a thin superficial layer on top of the vessel during the laser pulse. This is likely to be insufficient to coagulate or thrombose the whole vessel [11]. In comparison to FLPDL, IPLS provides longer pulses (0.5–30 ms), and thus, sufficient high energy densities. The pulse duration of the IPLS flash ranges well below the thermal relaxation time of dermal cells, thus avoiding involvement and damage of the surrounding tissue. Traditional continuous wave (cw) lasers, such as the Nd:YAG (1,064nm) laser, have also been used to treat deep seated blood vessels, e.g., in subcutaneous hemangiomas [35–38]. However, the wavelength is absorbed by water and, to a certain degree, by melanin and hemoglobin. Therefore, as with the CO_2 laser, tissue damage is relatively nonspecific. Additionally, the cw mode causes an extended thermal damage zone. Thus, such adverse effects as scarring and textural or pigmentary changes were common [10,34,39].

Using IPLS, splitting light into double and triple pulses with delay times between 0.5 and 500 ms is possible. Thus, venous malformations or cavernous hemangioma can be treated effectively by additional heating [40–42]. This split light application ensures adequate cooling of the epidermis and dermis between the flashes.

The described innovative technical requirements of IPLS concur with our observations in this study. So that the deep venous vessel structure can be reached and effectively thermally damaged, the 590 nm cut-off filter and the long pulse mode with relatively high energy densities (average of 80.4 J/cm^2) were most frequently used. Mostly triple pulse sequences with 5.0–8.7 ms pulses each were applied to protect the epidermis. With these parameters, we could achieve good results on our patients with venous malformations. In the course of this, the success of the therapy seems to also depend upon the size of the lesion to be treated. Venous malformations smaller than 100 cm^2 reached good to very good clearance after two to nine treatments. Eighteen treatments were needed for good clearance of lesions larger than 100 cm^2. In the cases, treatment was continued until no further lightening was visible. The number of sessions for larger lesions appears high, however they were tolerated by the patients because a treatment with FLPDL had caused little or no lightening. Morelli et al. reported similar results in a study of the treatment of port wine stains with FLPDL; 32% of the patients with port wine stains smaller than 20 cm^2 showed 100% clearance in comparison with 8% of the patients with larger port wine stains [43].

Adverse reactions were predictable. In the current study, prolonged erythema and swelling were observed relatively often (23.6% and 17.9%, respectively). Blisters and crusting were predominantly in VMA with thick nodular parts. The utilization of higher fluences seems to cause epidermal damage due to scattering of light and conduction of heat from especially large vessels to the surrounding tissue. Transient changes in pigmentation, e.g., hypopigmentation or hyperpigmentation and scarring, were relatively infrequent (1 of 106, 0.9%, respectively). Juxtaposed results to the incidence of side effects were described in studies using IPLS. Although transitory adverse effects were rare in the Goldman/Eckhouse study [16] (blisters 2%, crusting 0.4%, hypopigmentation 3%, hyperpigmentation 4%), Green [44] observed a higher incidence of blisters (42%), hypopigmentation (20%), hyperpigmentation (50%) and scarring (21% vs. 0.5% in Goldman/Eckhouse study) using IPLS for treatment of leg telangiectases. In comparison, FLPDL caused post-purpura pig-

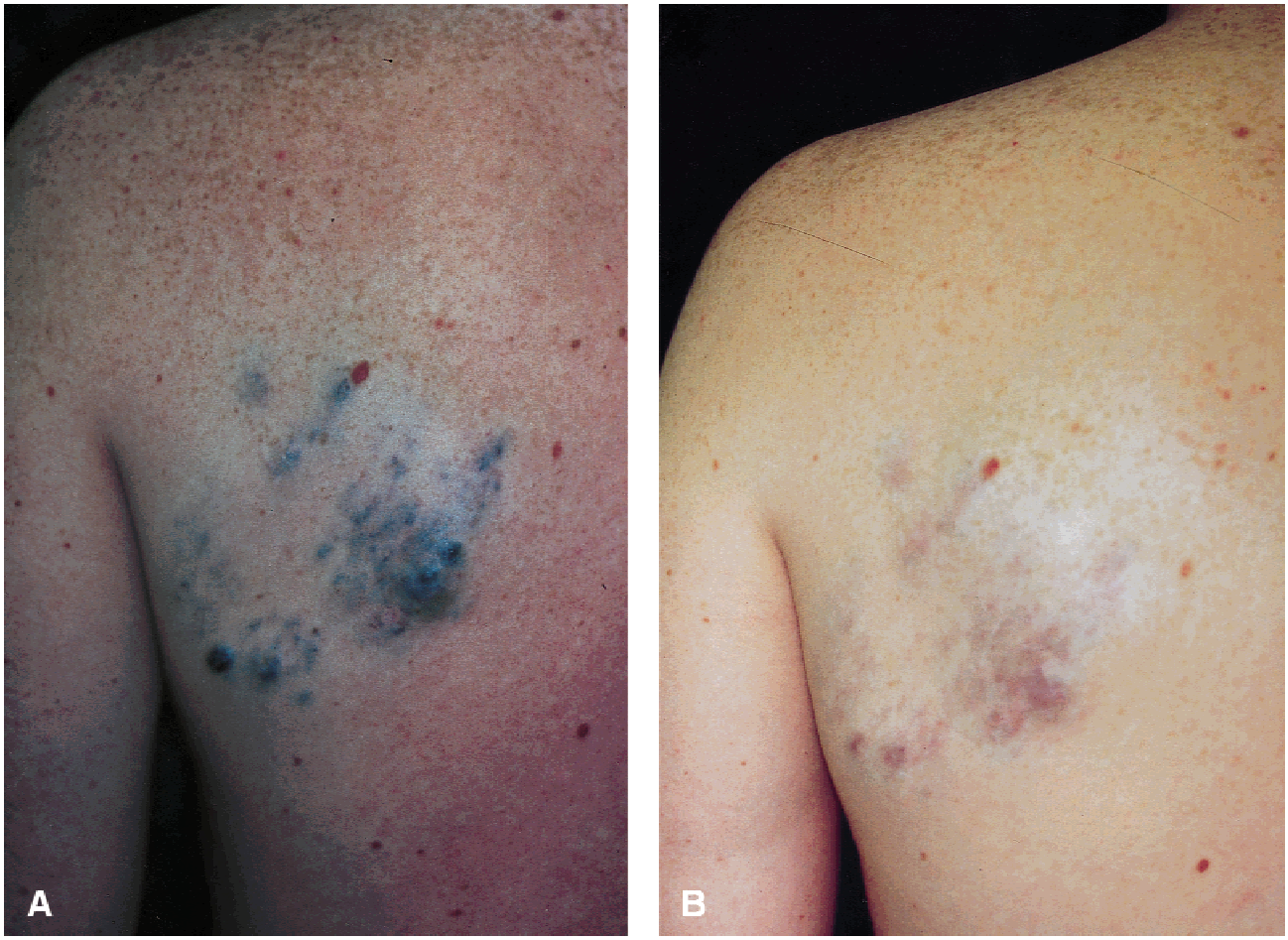

Fig. 2. **A:** A 31-year-old man with large and deep-seated (up to 2 cm under the surface) venous malformation on the left shoulder. **B:** Good (70%) clearance after 14 treatments with the PhotoDerm VL® with slight hypopigmentation.

TABLE 3. Side Effects During Venous Malformation Therapy by IPLS

Side effects	Appearance of side effects	(%) Total number of sessions (n = 106)
Prolonged erythema	25	23.6
Prolonged swelling	19	17.9
Blisters	3	2.8
Crusting	5	4.7
Bleeding	1	0.9
Post-treatment pain	6	5.7
Hypopigmentation	1	0.9
Hyperpigmentation	1	0.9
Scarring	1	0.9

mentation reported at a frequency of 9 to 57% [9,34,45–48] and post-inflammatory hypopigmentation in 2% to 10% [34,47,49–51].

The success rate with venous malformations, combined with a relatively low incidence of side effects, makes IPLS a useful alternative for adjunctive or primary treatment of venous malformations. We think IPLS will find a firm place in the therapy of vascular lesions, especially venous malformations. However, what we have still awaits large, critical, and especially prospective clinical studies and, possibly, more refined treatment parameters.

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